part of the Bolivian alti-plano, or high plateau, will be determined. The relations between this now vanished lake and Lake Titicaca have never been investigated, and the key to the problem must be sought in the outlet of the Titicaca basin. There, also, must be sought the key to much of the earlier history of the Titicaca depression. The Tiahuanaco valley and its celebrated ruins will be studied in relation to the supposed ancient levels of Lake Titicaca and to the limits of food production in the valley to-day.

The expedition will sail for Buenos Aires via Southampton, England, leaving New York on April 26, on the *Oceanic* of the White Star Line. Professor Bowman will be accompanied by Mr. H. S. Palmer, a graduate student in the Department of Geological Sciences at Yale, and for a part of the time also by a surveyor to be employed in South America.

Professor Bowman's field researches in South America have contributed materially to our knowledge of the topography, the fluvial systems and the climatic conditions of the desert, mountain and plateau regions he has traversed; and the emphasis he always places upon the importance of studying the interrelations between man and his environment has added richly to his results. It was highly desirable that Professor Bowman should have an opportunity to complete his work in the part of South America which he will now revisit, and the American Geographical Society is glad to further this consummation.

THE SEVENTEENTH GENERAL CONFERENCE OF THE INTERNATIONAL GEODETIC ASSOCIATION

By WILLIAM BOWIE
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The International Geodetic Association met in conference in the City of Hamburg, Germany, in September, 1912, the delegates being guests of the State of Hamburg. This conference was especially interesting and important, as it was held on the fiftieth anniversary of the founding of the Association.

A formal session opened the conference, with the President of the Association, General Bassot, in the chair. Senator Dr. von Melle of the State of Hamburg delivered the address of welcome, which

was responded to by the President. Among the other addresses were those by the Secretary of the Association, Prof. Dr. van de Sande Bakhuyzen, and the Director of the Central Bureau of the Association, Prof. Dr. Helmert, who reviewed the history and work of the International Geodetic Association during its first fifty years. The meetings were held in one of the rooms of the Vorlesungsgebäude.

At the sessions from the 18th to the 27th, when the conference adjourned, reports were presented by the standing committees on the different branches of geodetic work and research and by the delegates representing the twenty nations which took part in the conference. These nations were Austria, Belgium, Chile, Denmark, France, Germany, Great Britain, Greece, Hungary, Italy, Japan, Mexico, Netherlands, Norway, Rumania, Russia, Spain, Sweden, Switzerland, and the United States of America. The delegates from the United States were Mr. O. H. Tittmann, Superintendent of the U. S. Coast and Geodetic Survey, and the writer.

The reports covered the progress made during the past three years since the Sixteenth General Conference, held in England in 1909.

Of special interest to the geodesist and geographer in the United States are the reports of work done in Mexico and in this country, although there was much of interest reported by the delegates of the other nations and by the standing committees of the Association, notably that on the variation of latitudes. All of these reports will be printed in full in the *Proceedings* of the conference.

Mexico has extended a primary triangulation from the Pacific Ocean to the Rio Grande along the 98th meridian, an arc of about ten degrees. Parties of the U. S. Coast and Geodetic Survey are now in the field in Texas, where they will make a connection between this Mexican arc and the completed arc of primary triangulation which extends along the 98th meridian in the United States from Alice, Texas, to the Canadian border. This United States arc is twenty-three degrees in length. When the arcs of the two countries are connected there will be a meridian arc of 33°, or 2,270 statute miles, the longest meridional arc of primary triangulation in the world.

A gravity base station has been established in Mexico from which a gravity survey will be made by the Mexican Geodetic Commission.

The report on the work in the United States, entitled "Geodetic Operations in the United States, 1909-12," was presented by Mr. Tittmann. Extracts from it are given below which show the pro-

gress made in this country in the different branches of geodesy. At the end of that report is given a list of the geodetic publications issued by the U. S. Coast and Geodetic Survey during the years covered.

Astronomy. The astronomical work consisted of twenty-five azimuths observed at stations of the Texas-California arc of primary triangulation and of the secondary triangulation in Washington state, one latitude station and seven longitude stations.

Triangulation and Base Measurements. The Texas-California arc, extending from a line of the 98th meridian arc in central Texas to a line of the Pacific Coast triangulation in southern California, was begun in November, 1908, and was completed in February, 1911.* This arc is 1,207 miles in length; the main scheme covers an area of 49,220 square miles; and 115 stations were occupied for angle measurements. This arc is of great geographic value as it coordinates a number of previously existing separate schemes of triangulation, including several along the international boundery between the United States and Mexico, and furnishes bases from which to extend other schemes for controlling topographic and other surveys.

A scheme of secondary triangulation was extended from the vicinity of Tacoma, Washington, to the Pacific Coast near Grays Harbor, and thence southward to the mouth of the Columbia River. The length of this scheme is 140 miles.

The Alaska and Canada Boundary Survey under the direction of Dr. W. F. King, representative for Great Britain, and Mr. O. H. Tittmann, representative for the United States, as commissioners, extended a triangulation 512 miles along the 141st meridian, the boundary between Alaska and Canada. (During the season of 1912 this triangulation was completed to the Arctic Ocean). By the end of the year 1911 the triangulation along the 49th parallel of latitude had been extended 1154 miles from the Pacific Coast, along the United States and Canada boundary, to the Red River. These two arcs of triangulation are not primary in character but their results are of much value for geodetic and geographic purposes. The Lake Survey, under the Corps of Engineers of the United States Army, added 125 miles to the primary triangulation of the Great Lakes.

Two primary bases were measured to control the Texas-California triangulation and several tertiary bases were measured on the 141st meridian and the 49th parallel triangulations.

Reconnaissance for Primary Triangulation. During the year

* Summarized in *Bull. Amer. Geogr. Soc.*, Vol. 43, 1911, pp. 447-448.

1911 and the first two months of 1912, 1,277 miles of reconnaissance (selection of stations) were made for triangulation along the 104th meridian to the north of Denver, Colo.; from Salt Lake, Utah, to Needles, Cal.; and from Huntsville, Ala., to Memphis, Tenn.

*Extension of U. S. Standard Datum.** Arcs of triangulation, 2,500 miles in extent, were computed in the Coast and Geodetic Survey office during the three years covered by the report, and placed on the standard datum. Maps showing the results of surveys controlled by triangulation on the standard datum should never need changes in the projection (the lines showing the arcs of the meridians and parallels of latitudes).

Precise Leveling. During the three years, 1909 to 1911, 2,148 miles of leveling of the highest order were added to the leveling net of the United States by the Coast and Geodetic Survey and 300 miles by other organizations.

A readjustment of the precise leveling net of the United States is now being made by the Coast and Geodetic Survey and it is expected that the resulting elevations will be held as *standard* for all surveying and engineering purposes.

Gravity. In the years 1909-1911, the intensity of gravity was observed at seventy-seven stations in the United States; these with the forty-seven old stations make one hundred and twenty-four in all. They are fairly well distributed over the entire country. At each of these stations the observations were made with the half-second pendulum apparatus, using the station at the Coast and Geodetic Survey as the base. That station had been connected with the station at Potsdam, Germany, where the absolute gravity has been determined by observations through a long series of years.

Geodetic Investigations. In 1909, Prof. J. F. Hayford, then Inspector of Geodetic Work in the Coast and Geodetic Survey, completed his two reports on the figure of the earth, which were published in that year. They were reported to the 1909 conference of the International Geodetic Association held at Cambridge and London. In his investigations he applied the theory of isostasy, which postulates that the earth's crust is in a state of approximate equilibrium and that each topographic feature above sea level is floated, so to speak, by a deficiency of mass in the earth's crust, which exactly balances the mass above sea level. Likewise, under the oceans,

* For a detailed explanation of this datum see pp. 65 to 68 of Coast and Geodetic Survey Special Publication No. 11, or other reports of the Coast and Geodetic Survey, which give the results of triangulation.

there is assumed to be an excess of mass which exactly balances the deficiency of mass in the oceans. The station errors, or deflections of the vertical, at the several hundred astronomical stations, which were also triangulation stations, were very greatly reduced by considering the deficiency and excess of mass, which is called the isostatic compensation. It was found that the most probable depth to which these compensating masses extend is about 122 kilometers (seventy-six miles). The shape and size of the earth as derived by Hayford from data only in the United States have a greater precision than previously determined values from deflections of the vertical in this or other countries.

Previous to the conference in 1909 Professor Hayford developed a new method of reducing gravity observations in which the theory of isostasy was considered. By this method the intensity of gravity at a station is corrected for the attraction at the station, of the topography of the whole earth and its isostatic compensation. At the meeting of the Association in 1909 he presented a preliminary report on his method and the results he had obtained in reducing fifty-six gravity stations in the United States and sixteen stations not in the United States.

In the preparation of the final report on the new method of gravity reduction and the results of eighty-nine stations in the United States, Professor Hayford had the writer associated with him, and they appeared as co-authors of the report. This report appeared early in 1912 as "Effect of Topography and Isostatic Compensation upon the Intensity of Gravity."*

A report on a supplementary gravity investigation was prepared by the writer, copies of which were presented to the delegates at the Hamburg conference. In this investigation all of the stations in the United States, 124 in number, were used. The most remarkable feature of this supplementary investigation is the deduction of the flattening of the earth, first, from all of the stations in the United States as one group, then, in two groups of stations, one in the eastern portion of the country and one in the western. The three derived values of the reciprocal of the flattening are, respectively, 298.4, 297.8 and 299.6. The remarkably close agreement of all these values of the flattening, from very few data and a small range in latitude, with the generally accepted best values depending upon extensive geodetic data, makes it appear that the new method of reduction is very close to the truth.

* *Special Publication No. 10* of the Coast and Geodetic Survey.

In his report to the conference, Mr. Tittmann made the statement: "It is hoped that the International Geodetic Association in the near future may reduce all the available gravity stations of the world by this method, for it is reasonably certain that a value of very great precision for the flattening could be deduced from the results."

Photographic Zenith Tube. A section of Mr. Tittmann's report was devoted to a description of this tube and the method of using it at the International Latitude Station at Gaitersburg, Maryland, by Dr. F. E. Ross. The object in view in designing and operating the photographic zenith tube for the determination of latitude was twofold: (a) increased precision in the latitude observations; (b) comparison of final results with results secured by the visual zenith telescope placed alongside and operated simultaneously with it, with special reference to the variation of the latitude curve, in the Kimura term, the aberration constant, and the so-called night error. The second object was considered to be of more importance than the first. In its main features and its general theory the instrument is a photographic adaptation of the Greenwich zenith tube designed by Sir George B. Airy (Greenwich Observations, 1854).

The instrument was mounted in May 1911 and the first photographs of stars were made in the following June. Up to July, 1912, about 2,000 stars had been photographed, including stars for latitude and for scale values. The photographs have all been measured twice, the apparent place reductions have been made, and the provisional latitudes determined. As the instrument had been in operation for one year only it was impossible to give any very definite results from the study of the observations.

Excellent progress was made in the geodetic work of this country during the past three years. Those portions of it which are of the greatest geographical value are the primary triangulation and the precise leveling, all in the interior of the country, which add to the framework from which will be extended a lower grade triangulation and leveling principally for the immediate control of topographic and boundary surveys.